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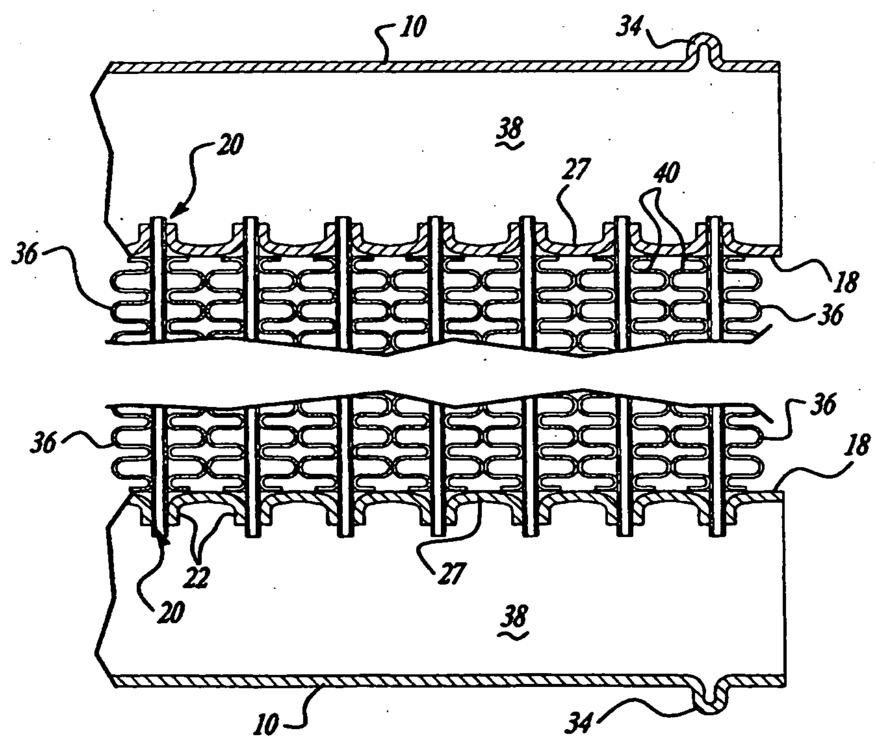
(54) Title: HEAT EXCHANGER WITH AN INTEGRATED TANK AND HEAD SHEET

(57) Abstract

A heat exchanger having a core of a plurality of cooling tubes (36) with a tank (10) at each end of the core tubes (36). The tanks (10) are formed with a plurality of cooling tubes (36) receiving apertures (20) along a side portion of the tanks (10). These apertures (20) receive the ends of the cooling tubes (36) directly into the tanks (10) and are attached to the tubes (36) by brazing. Since the cooling tubes (36) are received in apertures (20) formed in the tanks (10) themselves, the need for a separate head sheet at the end of the core is eliminated thereby eliminating the need for sealing of a head sheet to a separate tank (10). The tanks (10)are preferably formed in a hydroforming operation to shape the tanks (10) from a tubular blank.



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HEAT EXCHANGER WITH AN INTEGRATED TANK AND HEAD SHEET

CROSS REFERENCE TO RELATED APPLICATION

This application is a Continuation-in-Part of U.S. Patent Application No. 09/080,475, filed May 18, 1998.

BACKGROUND AND SUMMARY OF THE INVENTION

The present invention relates to heat exchangers having a core of cooling tubes with a tank at each end of the core and in particular to a heat exchanger in which the core tubes are directly joined to the tank without an intermediate head sheet.

Typical liquid to air heat exchangers, such as automotive radiators, include a core assembly of a plurality of cooling tubes with fins. The cooling tubes extend between spaced head sheets or header plates. The end of the tubes extend through apertures in the head sheets and are sealed thereto, typically by brazing. A tank formed as a three dimensional stamped metal body or a molded plastic body having an open side, is joined to each of the head sheets and sealed thereto to form a closed tank at each end of the core. Fluid flows from one tank through the cooling tubes to the other tank. A second fluid, typically air, passes between the fins to remove heat from the cooling tubes and thereby cool the fluid in the tubes as it flows from one tank to the other.

The seal between each tank and the head sheet is difficult to properly form and can be the source of leaks during the use of the heat exchanger. Accordingly, it is an object of the invention to provide an improved heat exchanger construction that overcomes the problems associated with the sealing of the core head sheet to the tank.

The present invention overcomes the problems in the prior art by forming the tank and head sheet as an integral, single piece body. A closed tank is formed with apertures along one side for receiving the cooling tubes. The tubes are then inserted directly into the tank. This eliminates the need for a separate head sheet and the need to seal the separate head sheet to the tank. The tubes are sealed to the tank by brazing, in a conventional manner, for constructing a heat exchanger.

The heat exchanger tanks are shaped by a hydroforming process in which an elongated tubular blank is first placed in a die cavity that matches the tank s desired shape. The interior of the tubular blank is sealed and then highly pressurized with a fluid, such as water or oil, so that its outer surface is forced to take the shape of the cavity.

The hydroforming cavity includes inwardly projecting chisel points or punches. After the tube assumes the cavity shape the punches are actuated and pierce the tank.

During hydroforming, outwardly projecting ribs are formed between each of the cooling tube receiving apertures to stiffen the tank. These ribs extend in a circumferential direction relative to the tube longitudinal axis. Cylindrical projections from the tube are also formed during hydroforming. These projections form inlet and outlet necks for the tanks. During hydroforming, the cylindrical projections have closed ends. These ends are later removed, forming the open cylindrically shaped necks.

The open end or ends of the tube blank are closed with an end cap after the tank is hydroformed. The end caps are sealed to the tank by brazing.

An auxiliary oil cooler can be disposed in one of the tanks. The inlet and outlet tubes of the auxiliary cooler extend through one of the tank end caps. The end cap at the opposite end of the tank can be shaped to form a support ledge for supporting the end of the auxiliary cooler. The fluid in the oil cooler is cooled by the first fluid which is typically water or a mixture of anti-freeze and water. Alternatively, the auxiliary oil cooler can be attached to one of the tanks and the other of the tanks to provide structural support thereto and to permit the auxiliary oil cooler to be cooled by a second fluid, such as air.

During hydroforming, outwardly or inwardly extending protrusions can also be formed on the tank to locate the heat exchanger on a rubber mount when attaching the heat exchanger to a supporting structure. The protrusion is typically disposed into a groove in the rubber mount. The rubber mount isolates the heat exchanger from vibration of the support structure, such as an automobile.

Further objects, features and advantages of the invention will become apparent from a consideration of the following description and the appended claims when taken in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a prospective view of a radiator tank constructed according to the present invention;

FIG. 2 is a sectional view of the heat exchanger tank as seen from substantially the line 2-2 in FIG. 1;

FIG. 3 is an enlarged sectional view of the circled portion of FIG. 2;

FIG. 4 is an enlarged sectional view of an alternative embodiment of the circled portion in FIG.2

FIG. 5 is a sectional view of a heat exchanger having two tanks and cooling tubes therebetween;

FIG. 6 is a side elevational view of an inlet/outlet to the radiator tank;

FIG. 7 is sectional view of a tank having an auxiliary oil cooler therein;

FIG. 8 is an enlarged sectional view of an alternative embodiment of the circled portion in FIG. 2;

FIG. 9 is a side elevational view of an overflow protrusion to the radiator tank;

FIG. 10 is a side elevational view of a radiator cap protrusion for the radiator tank;

FIG. 11 is a side elevational view of a radiator cap protrusion and radiator fill elbow for the radiator tank;

FIG. 12 is a sectional view of a heat exchanger having an auxiliary cooler connecting the top tank to the lower tank;

FIG. 13 is a side view of FIG. 12;

FIG. 14 is an enlarged cross-sectional view of the tubular support with a turbulator; and

FIG. 15 is an enlarged cross-sectional view of the tubular support with dimples.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

In reference to FIG. 1, a heat exchanger tank 10 is shown which is made according to the present invention. The tank 10 has a generally tubular body and is shaped by a hydroforming operation. A tubular blank is placed between a pair of dies that close over the tube to create a sealed cavity. The surface of the die cavity matches the desired final shape of the tank 10. The interior of the tubular blank is sealed and

highly pressurized with a fluid, such as water or oil, so that its outer surface is forced to take the shape of the cavity. The tank 10 has ends 12 and 14. both of the ends are open. The hydroforming liquid is introduced into the tubular blank through the open ends. During the hydroforming process, an inlet/outlet 16 is formed which projects or extends from the side of the tank. The tank side portion 18 is generally flat in the preferred embodiment.

A plurality of chisel points are mounted into the die cavity tool. After the hydroforming operation, the chisel points pierce the tank forming, a plurality of cooling tube apertures 20 in the tank side portion 18. The apertures 20 can be made of any suitable shape including round, oval or any of the variety of shapes used to form holes in heat exchangers or which could be used in heat exchangers. Such apertures 20 may be formed by the use of round, oval chisel point or dog-boned chisel point punches. Additionally, the apertures 20 may also be formed with a punch which includes a ferrule form and lead-in to assist in the assembly of tubular core members into the head tank. With reference to FIG. 3, a cooling tube aperture 20 is shown in greater detail. As a result of the chisel point pierce operation, the aperture is surrounded by an upstanding ferrule 22. The upstanding ferrule 22 provides a relatively large surface area 24 for contact with a cooling tube that is subsequently inserted into the hole 20. An alternative embodiment of the ferrule is shown in FIG. 4. There a 3-sided punch is used which forms an upstanding slug 26 to one side of the aperture 20.

Between adjacent tube apertures 20, an outward projecting rib 27 is formed. The ribs extend in a circumferential direction transverse to the tube length to stiffen the tank, and provide a tube lead in for assembly.

With reference to FIG. 6, an inlet/outlet 16 is formed during the hydroforming process. The inlet/outlet neck 16 has a closed end portion 28 which may be formed hemispherically as shown in FIG. 6. The closed end portion 28 is removed by cutting the inlet/outlet along the line 30, thereby creating an open end on the inlet/outlet. A raised rib 32 around the neck assists in retaining a hose on the neck. Identically shaped tanks can be used on both ends of the core. On one tank, the neck 16 will be the heat exchanger inlet. On the other tank, it will be the heat exchanger outlet. Both tanks can be made with the same hydroform die. An assembled heat exchanger is shown in greater detail in FIG. 5. A pair of identical tanks 10 are shown spaced from one

another. The tanks are oriented with their two flats side positions 18, with the cooling tube apertures, facing each other. The ends of a plurality of cooling tubes 36 are inserted into the cooling tube apertures 20 of each tank. The tubes 36 are typically surrounded by a plurality of flat or corrugated fins 40 to assist in heat transfer from the tubes. The tubes are subsequently brazed to the tanks 10 in a furnace brazing operation in a conventional manner for manufacturing heat exchangers. This provides a sealed connection between the cooling tubes 36 and the tanks 10. The tubes can be at any cross sectional shape but are preferably flat tubes. The tube apertures 20 are correspondingly slot shaped. The slots are oriented parallel to the ribs 27, in a circumferential direction, relative to the tank.

The tanks can be hydroformed with protrusions 34 to locate the tank on a rubber mount, etc., when mounting the heat exchanger on a support structure, such as an automobile body.

The tanks and tubes can be made of aluminum, brass, steel, stainless steel or any of a variety of metals used in heat exchangers or which could be used in heat exchangers.

With reference to FIG. 7, a tank 10 is shown sealed at the ends by a pair of end caps 42 and 44. The end caps are stamped to shape and are also clad so that they can be brazed to the tank ends. In the embodiment shown in FIG. 7, the tank houses a secondary or auxiliary oil cooler 46 used to cool engine oil or transmission oil in an automotive radiator. The auxiliary cooler has an inlet pipe 48 and an outlet pipe 50 extending through the end cap 44. The end cap 42 is stamped in a shape to form a support ledge 52 to support the distal end 54 of the auxiliary cooler. The end caps are mechanically joined to the tank by toggle locks or other metal crimping operations to hold the end caps in place during assembly and prior to the brazing process.

The heat exchanger may also include a pair of side supports 60 and 62 shown in FIG. 7 . These side supports extend between the two tanks 10 and hold the tanks in place relative to one another. These side supports include an outward extending flange 64 to stiffen the side supports. However, at the ends of each side support, there is a small gap 66 in the flange. This forms a stress relief to allow the heat exchanger to expand and contract during thermal cycling.

Those skilled in the art will recognize that the tube endings 36 need not be brazed to the cooling tube apertures 20 of each tank. Alternatively, an elastomeric grommet or gasket 78 may be inserted between the tube and the apertures, as shown in FIG. 8.

The heat exchanger of the present invention provides an integrated tank and head sheet. The cooling tube apertures are formed directly into the tanks. This avoids the need for a separate head sheet connected to the cooling tubes which must subsequently be sealed to a tank. In a preferred method of manufacture of the heat exchanger, the tanks are hydroformed to the desired shape and the cooling tube receiving apertures are pierced into the tank after the hydroforming operation. The heat exchanger is subsequently assembled by inserting the cooling tubes directly to the tanks and sealing by brazing, or other joining process.

Optionally, an overflow protrusion 70 is formed in the inlet 16 of the first tank 10, as shown in FIG 9. The overflow protrusion 70 has a closed end 72 which is removed by cutting the protrusion along the line 74 thereby creating an open end in the protrusion 70. The overflow protrusion 70 can be threaded, potted with epoxy or filled with an adhesive to connect it by means of a line (not shown) which is connected to an overflow bottle (not shown).

Additionally, the first tank may be formed with a radiator cap protrusion 80 in the first tank, as shown in FIGS. 10 and 11. The radiator cap protrusion 80 has a closed end 82 and it is cut along line 74 to form an opening in the radiator cap protrusion 80. A plastic molded radiator fill elbow 83 is attached to the protrusion 80 by means of an epoxy or other suitable adhesive. A cap 85 threadably engages tangs on the radiator fill elbow 13 to cover the fill hole.

The preferred mode of practicing the present invention is directed to heat exchangers that are widely used in both mobile and industrial applications. In many applications only one hot fluid, for example, engine coolant such as anti-freeze and water, transfers its heat by means of cooling tubes to a second fluid such as air, as shown in FIG. 1. In other applications, one hot fluid typically is directed into the heat exchanger and the heat from one hot fluid is cooled by a second hot fluid, typically engine coolant. Then the second hot fluid is cooled by a third fluid such as air. The first hot fluid which is normally the hottest of all three fluids such as, for example, engine or

transmission oil flows into the heat exchanger where the first hot fluid transfers its heat to a second hot fluid. The second hot fluid then is cooled by means of the cooling tubes by the third fluid, as shown in FIG. 7, which is defined herein as a serial cooling system.

In another alternative embodiment of the present invention, a parallel cooling system is defined herein as a heat exchanger that is also used in both mobile and industrial applications. For example, more than one hot fluid flows into a heat exchanger where the two hot fluids are cooled by a third fluid, as shown in FIGS. 12 through 15. For example, the first hot fluid flows into the heat exchanger and its heat is transferred by means of cooling tubes to the third fluid. A parallel cooling circuit is provided and the second hot fluid flows into a separate cooling circuit wherein the second hot fluid flows through the tubular flow member 87 which transfers its heat to the third fluid.

Thus, a secondary auxiliary fluid cooler 86, typically engine oil or transmission oil and a third fluid such as air is located adjacent to the automotive radiator, as shown in FIGS. 12 and 13. The auxiliary cooler 86 has a hollow tubular member 87 which replaces the side supports 60, 62. The hollow tubular member 87 has a passage 88 formed therein. The turbulator member 89 is inserted into the passage to cause the fluid therein to be moved by fins in the flow passage to cause the fluid to be turbulated to enhance heat transfer from the tubular member to the air as is well known in the prior art. Optionally, the turbulator can be brazed to the inner walls of the tubular member. To prevent flow bypass and to stiffen the walls of the tubular member 87. Alternatively, the hollow tubular member 87 may be formed with a number of dimples 90 which protrude into the passage 88 in an alternating pattern so as to turbulate the fluid therein as is known in the art. The ends of the hollow tubular member are closed by end forming and then flattened to seal the ends of the tubular member 17 closed. The end forming creates an opening into which a connector 92 can be inserted. The connector is brazed to the opening in the end formed end of the tubular member 87. The hollow tubular member is relatively flat and located adjacent to one of the plurality of cooling tubes 36. The width of the tubular member can vary depending on the application requirements. However, preferably the tubular member is same width as the cooling tubes 36. The hollow tubular member 87 is fastened to the tanks 10 by means of a pair of retaining tabs 93 that are formed in the oil cooler end caps 94. The tabs 93 capture

the hollow tubular member 87 between the oil cooler end caps 94 for a purpose to be described later on. On the bottom of the hollow tubular member 87 is a second pair of retainer tabs 95, which are formed in the oil cooler end cap 96. The tabs 95 are formed so as to capture the bottom end of the hollow tubular member 87. The tabs 95 are fastened to a hollow tubular member 87 by means of a brazing. A series of discontinuous braze joints also connect the hollow tubular member 87 to the cooling fins 36. The top retaining tabs 93 permit the hollow tubular member 87 to slide past the tabs 93 to permit thermal growth of the hollow tubular member. Connection of the inlet/outlet of the hollow tubular member is formed by means of the connector 92. Thus, either engine oil or transmission oil may be made to flow through the hollow tubular member and transfer heat from the oil to the ambient surrounding air. It has been found that it may be advantageous to stack several hollow tubular members adjacent to each other in order to cool the hot engine oil or transmission fluid faster or to a lower fluid temperature as is well known in the art.

The hollow tubular member 87 may also be used as a side support for the heat exchanger tanks only. In this condition, the hollow tubular member 87 is flattened at each end and the end forming process would be eliminated.

Those skilled in the art will recognize that the heat exchanger described herein can be used for multiple applications where it is desired to cool hot fluids by means of a cooler fluid. Thus, the present invention can be used in applications such as charged cooled air-to-air coolers, industrial heat exchangers or radiators, to name just a few applications. The heat exchanger can also be used in refrigeration units, as a chiller. Alternatively, the heat exchanger may be used to cool air or other fluids.

It is to be understood that the invention is not limited to the exact construction illustrated and described above, but that various changes and modifications may be made without departing from the spirit and scope of the invention as defined in the following claims.

IN THE CLAIMS

1. A heat exchanger having a first tank having a fluid inlet and a second tank having a fluid outlet, a plurality of cooling tubes each having a first end and a second end, said heat exchanger comprising:

First and second elongated hollow metal bodies each made of a single piece and each having ends, at least one of each hollow bodies being open, the open end being closed by a separate end cap sealingly joined to the hollow bodies whereby the hollow bodies form first and second tanks; each of said tanks having a side portion, said side portion of each of said tanks having a plurality of tube receiving apertures therein, the first end of said plurality of cooling tubes projecting through said tube receiving apertures of said first tank, the second end of said plurality of cooling tubes projecting through said tube receiving apertures of said second tank, the plurality of cooling tubes being sealingly joined to said first and second tanks in a leak proof manner whereby a fluid can flow into said first tank through the inlet, flow from the first tank through the cooling tubes to a second tank and flow from the second tank through the outlet.

2. The heat exchanger of Claim 1 wherein said plurality of tube receiving apertures are formed by a dog-boned chisel point punch.

3. The heat exchanger of Claim 1 wherein said plurality of tube receiving apertures are formed by a round punch.

4. The heat exchanger of Claim 1 wherein said plurality of tube receiving apertures are formed by an oval chisel point punch.

5. The heat exchanger of Claim 1 wherein said plurality of apertures are formed with a punch, said punch having a ferrule form and a lead-in.

6. The heat exchanger of Claim 1 wherein said cooling tubes are flat tubes and the tube receiving apertures are slotted apertures oriented in the tanks to extend in a circumferential direction of the tanks.

7. The heat exchanger of Claim 1 further comprising an auxiliary cooler disposed in one of the tanks, the auxiliary cooler having an inlet and outlet extending through the end cap.

8. The heat exchanger of Claim 1 further comprising a support member extending between the first and second tanks and joined thereto to hold the tanks in position relative to one another, the support member having means to relieve stress during thermal cycling of the heat exchanger.

9. The heat exchanger of Claim 1 further comprising at least one hollow member adjacent to one of said plurality of cooling tubes and connected to said first and second tanks.

10. The heat exchanger of Claim 1 wherein said tanks are formed by hydroforming.

11. The heat exchanger of Claim 1 wherein said apertures are oval.

12. The heat exchanger of Claim 1 wherein said apertures are round.

13. The heat exchanger of Claim 9 wherein said hollow member having a passage.

14. The heat exchanger of Claim 9 wherein said hollow member having a turbulator inserted in said passage.

15. The heat exchanger of Claim 9 wherein said outer periphery of said hollow member is dimpled.

16. A method for making a heat exchanger with a pair of elongated tubes having at least one open end and a plurality of cooling tubes having a first and a second end, said method comprising:

placing one elongated tube into a die cavity and closing the cavity;

forming one elongated tube to a desired shape by filling the tube with a pressurized fluid to deform the tube outward into engagement with the surface of the die cavity;

forming tube receiving apertures in the tube along one side portion of the one elongated tube while the tube is in the die cavity;

removing the one elongated tube from the die cavity;

closing the at least one open end of the one elongated tube with an end cap to form a first tank;

forming a second tank with the other elongated tube by repeating the above steps;

inserting the first end of each cooling tube into the tube receiving apertures of said first tank.

17. A method as claimed in Claim 16 wherein said tube receiving apertures are formed using a dog-boned chisel point punch.

18. A method as claimed in Claim 16 wherein said tube receiving apertures are formed using a round punch.

19. A method as claimed in Claim 16 wherein said receiving apertures are formed using an oval chisel point punch.

20. A method as claimed in Claim 16 wherein said tube receiving apertures are formed with a punch, said punch having a ferrule form and a lead-in.

21. A method as claimed in Claim 16 wherein said forming step includes a chisel point punch operation.

22. A method as claimed in Claim 16 wherein said forming step includes a 3-sided punch operation.

23. A method as claimed in Claim 16 wherein said cooling tubes are flat tubes and the tube receiving apertures are slotted apertures oriented in the tanks to extend in a circumferential direction of the tanks.

24. A method as claimed in Claim 16 wherein connecting the first and second tanks with a support member extending therebetween and holding the tanks in position relative to one another, the support member having means to relieve stress during thermal cycling of the heat exchanger.

25. A method as claimed in Claim 16 wherein disposing an auxiliary cooler in one of the tanks, the auxiliary cooler having an inlet and outlet through the end cap.

26. A method as claimed in Claim 16 wherein said forming step includes hydrofroming.

27. A method as claimed in Claim 16 further comprising:

connecting a hollow member to said first and second tanks and adjacent to one of said plurality of cooling tubes.

28. A method as claimed in Claim 21 wherein said chisel point pierce operation forms an upstanding ferrule.

29. A method as claimed in Claim 22 wherein said 3-sided punch forms an upstanding slug to one side of the aperture.

30. A method as claimed in Claim 27 wherein said hollow member having a passage.

31. A method as claimed in Claim 27 wherein the outer periphery of said hollow member is dimpled.

32. A method as claimed in Claim 27 wherein said hollow member having a turbulator inserted in said passage.

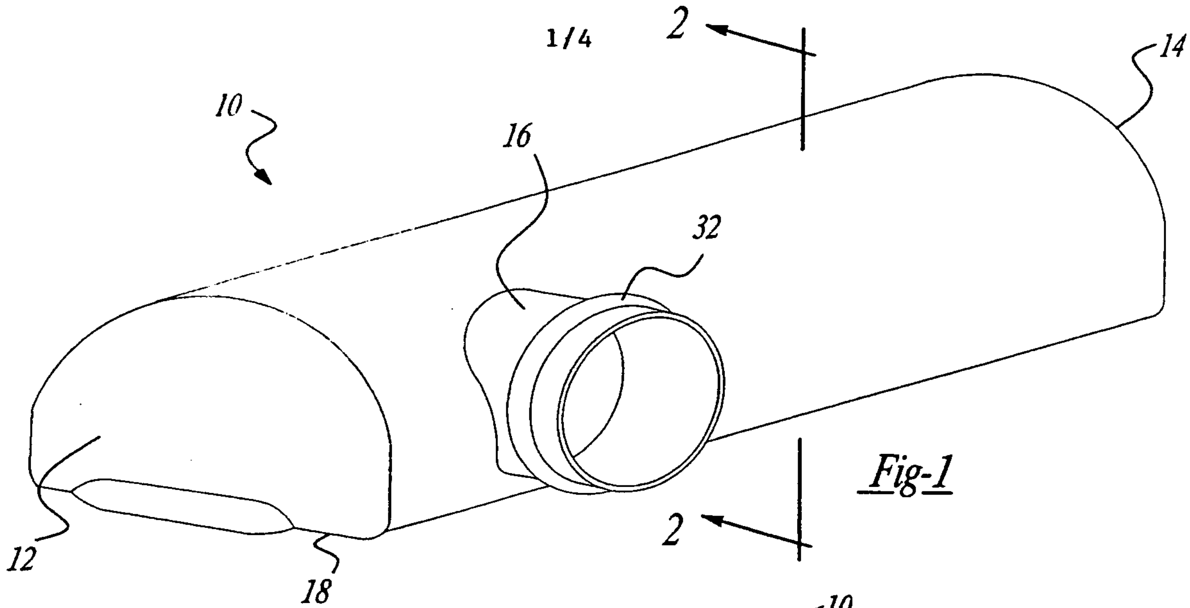

Fig-1

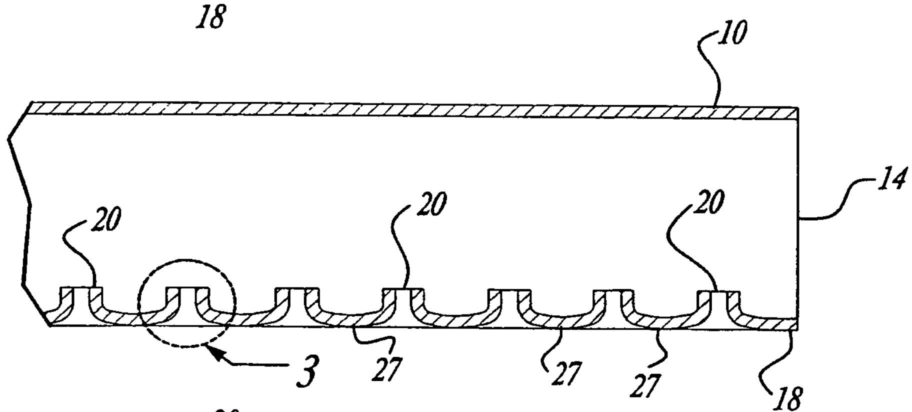

Fig-2

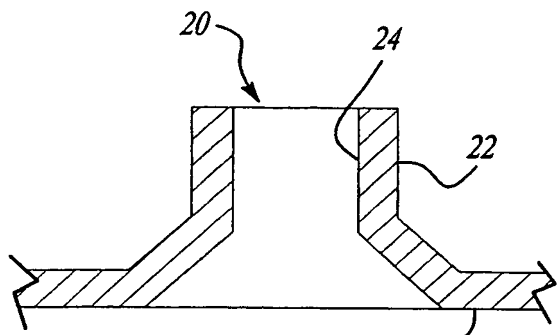

Fig-3

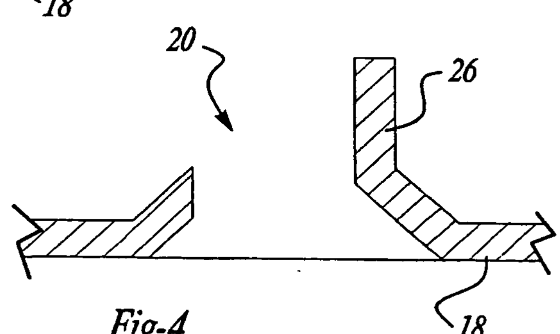

Fig-4

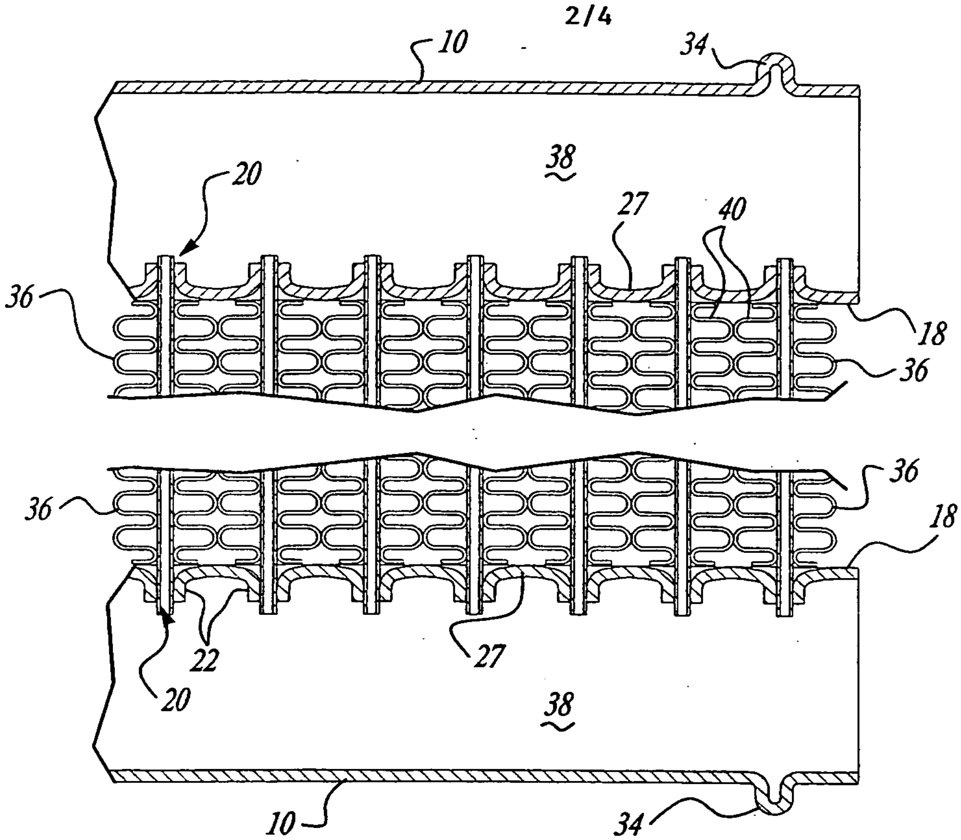

Fig-5

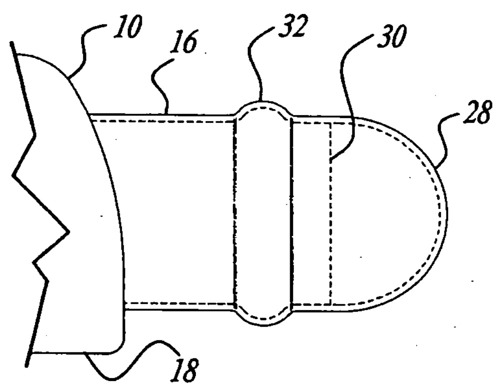

Fig-6

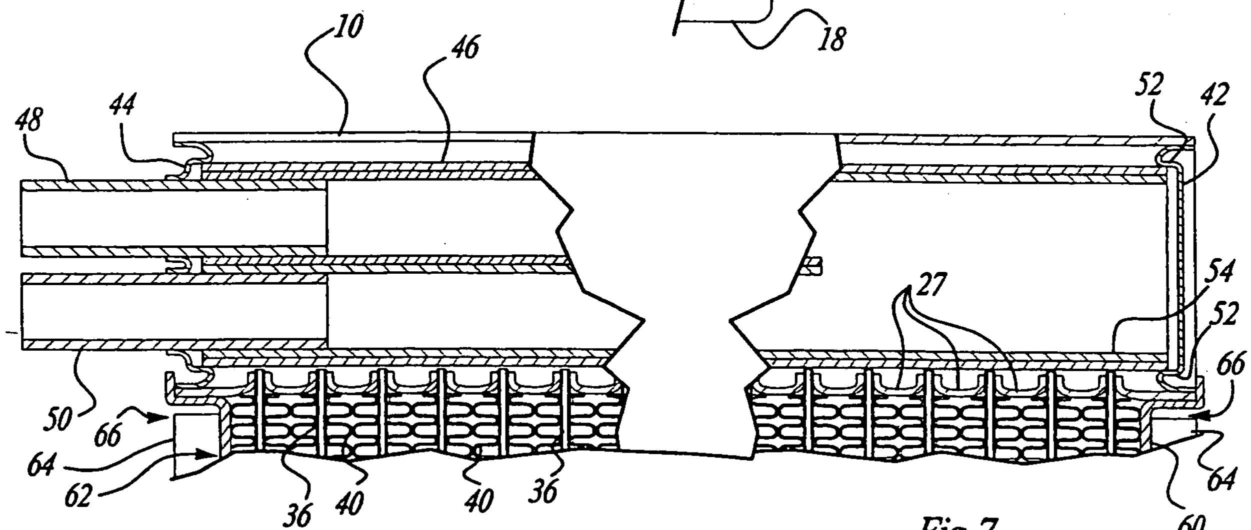

Fig-7

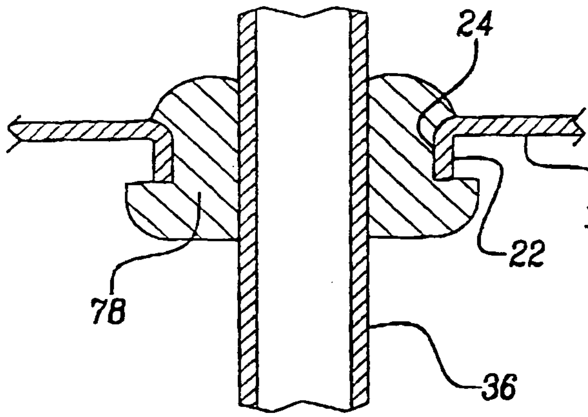

Fig-8

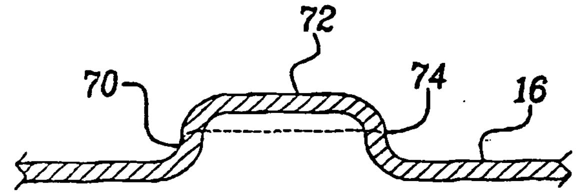

Fig-9

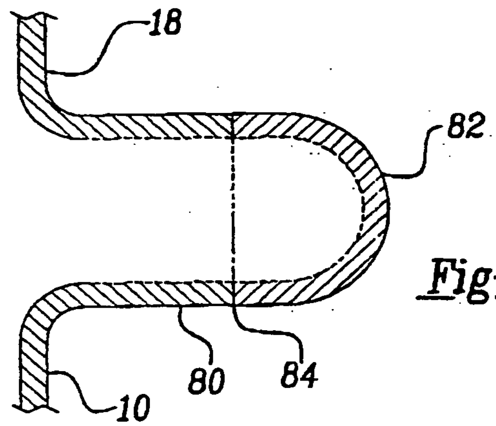

Fig-10

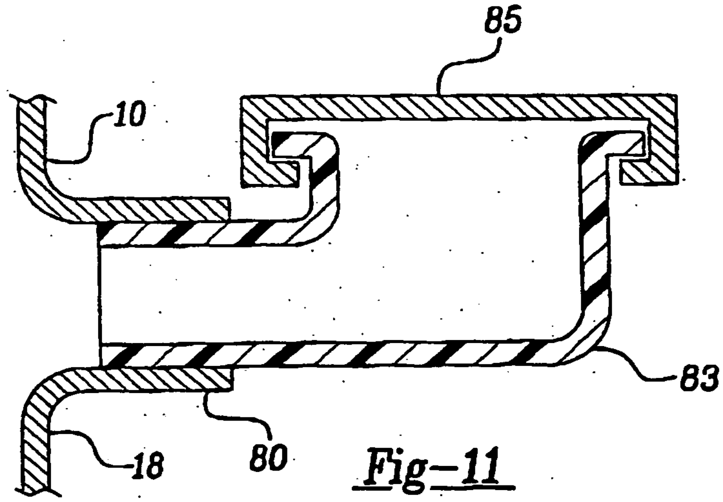

Fig-11

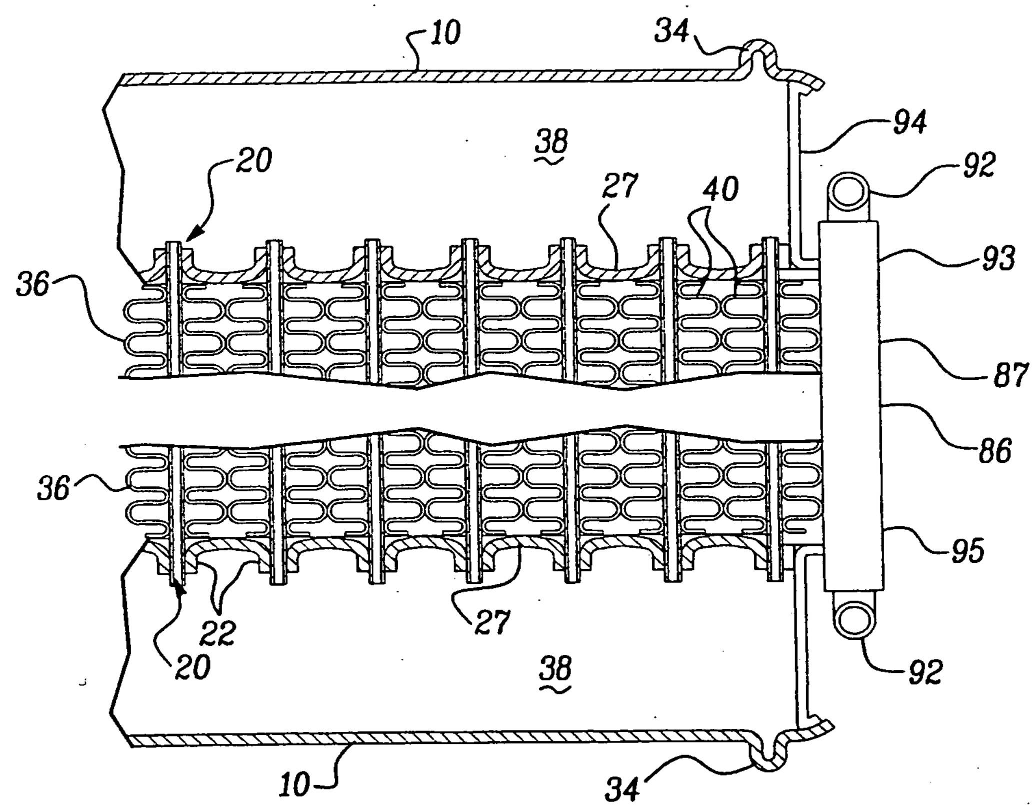

Fig-12

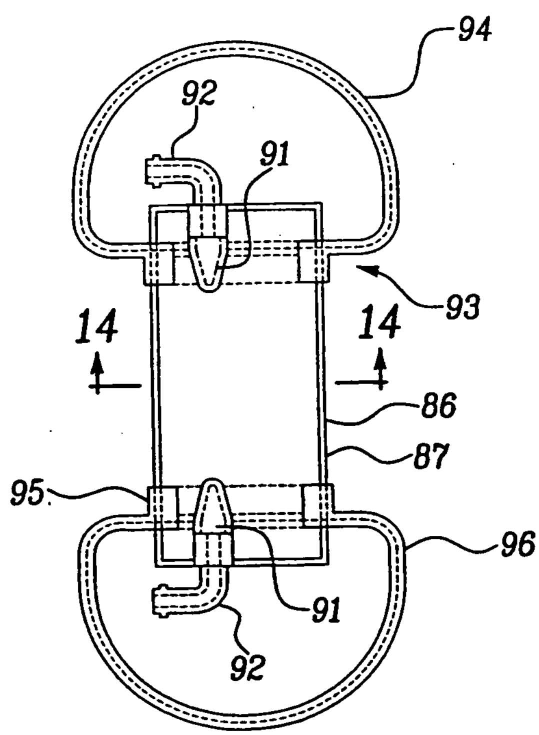

Fig-13

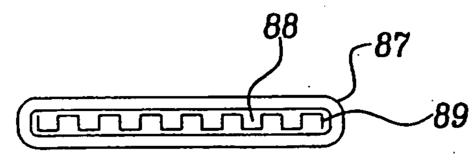

Fig-14

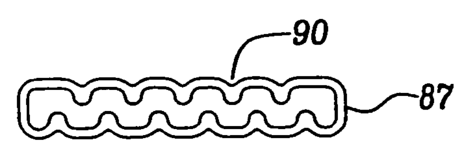

Fig-15

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 99/11069

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 F28F9/02 F28D1/04 B21D28/28

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 F28F F28D B21D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	US 5 737 952 A (RILK MARTIN ET AL) 14 April 1998 (1998-04-14) column 4, line 21 - column 8, line 33; figures	1,3-6, 11,12 8-10,13, 16, 18-21, 23,26,28
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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
31 August 1999	07/09/1999

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Van Dooren, M

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INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 99/11069

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	column 5, line 39 - column 6, line 43; figures 2-5	16,23,25
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